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UNITED STATES DEPARTMENT OF AGRICULTURE
BUREAU OF ENTOMOLOGY
FOREST INSECT INVESTIGATIONS

DAMAGE TO PINE SEEDLINGS BY THE PINE TIP MOTH,

Rhyacionia frustrana,

IN THE NURSERY AT THE STATE COLLEGE OF AGRICULTURE, ATHENS, GEORGIA

(Memorandum for Dr. Craighead)

by

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St. Paul, Minnesota
April 21, 1930

Miller
copy to Eddy Tree
Br. Sta. 6/20/30

St. Paul, Minnesota,
April 21, 1930.

MEMORANDUM FOR DR. CRAIGHEAD

Ref. - Damage to pine seedlings by the pine tip moth, Rhyacionia frustrana, in the nursery at the State College of Agriculture, Athens, Georgia.

During the investigations of the pine tip moth on the Nebraska National Forest, at Halsey, Nebraska, several insecticides have been found effective for dipping nursery stock in the spring to destroy tip moth eggs which are being laid at the time of digging. The object of this treatment is to prevent the spread of the pest in the egg stage on pine seedlings shipped out of the Forest for use in isolated private plantations - since the variety, R. frustrana bushnelli, of the eastern moth found in Nebraska does not overwinter in the tips but in the ground and the eggs are the only stage likely to be transported. The most serious damage in this plantation forest is the retardation of growth and deforming of seedling and saplings pines in the field, especially western yellow pine, and the work has been confined largely to parasites with which we are getting good results with a species introduced from the East. Work has also been started on the obtaining of more vigorous stock by the selection of seed trees from the nearest source etc., since the vigorous trees gradually outgrow the tip moth injury while the less vigorous are held in check and are occasionally killed by repeated attack.

The infestation in the nursery may run up to nearly 10% of the transplants but in most years is only about 2 or 3% of the stock infested and is not of a very serious nature, consequently no attempt has been made to reduce this injury in the extensive nursery beds. However, one of the most efficient and cheapest of the dips used, a white oil emulsion, was tested on small trees in the field last season as a spray against the egg stage of the tip moth and with

three applications during the egg laying period a great reduction in the amount of injury was obtained. If the damage to southern pine seedlings in the Georgia nursery is serious this method might be used to reduce the damage, and might also be used to protect small plantations.

The difficulty is that we know very little of the time of tip moth emergence, which is also the time of egg laying, in the Southeast, or even the number of broods that appear each season, and for this reason we cannot recommend a specific time for applying the spray. This would have to be determined by someone in the region. Although you wrote me a long while ago about the damage to loblolly and slash pine seedlings, a few notes even at this time of the season, on the habits of the insect and possibility of spraying, might be of help to those interested in the pest; and especially since the tip moth has been reported damaging reproduction and may become a common pest with more extensive plantations and areas of reproduction.

A brief account of "The tip moth in the Nebraska National Forest" is given in the Journal of Agri. Research, Vol. 35, No. 4, pp. 323-333, 1927.

This memorandum will, therefore include a few notes on the problem under the following headings:

- Possible time of moth emergence in Georgia.
- Notes on other stages of the tip moth - eggs; larvae; and pupae.
- Possibility of using insecticides.
- Time of spraying for the egg stage.
- Determining the period of moth emergence.
- The use and results with a white oil emulsion spray.
- Other insecticides that might be tested.
- And a brief summary.

TIME OF EMERGENCE OF MOTHS

Since there have been no definite observation made, to my knowledge, we can only estimate the number of broods and time of emergence of the adults of the pine tip moth at Athens, Ga. We do know that under conditions prevailing in Nebraska and around Washington, D. C., two complete broods develop each season, while at Bogalusa, La., four and possibly five distinct broods develop. In Georgia, therefore, it is likely that at least three separate broods of moths emerge during the season, and possibly four.

The first moths emerge from overwintering pupae in the infested tips, for the eastern species, soon after elongation of the new growth of pine begins, and emergence of this brood may continue for several weeks. I would expect the second brood of moths to appear in the later part of May, since they are said to emerge about the middle of June around Washington. This would leave time for a third brood about the middle of July, and possibly a fourth brood some 5 weeks later if the season is long enough.

NOTES ON OTHER STAGES OF THE INSECT

The Eggs

Egg laying begins soon after emergence of the moths and since this emergence may continue over a period of more than two weeks it is likely that the eggs of any particular brood could be found in the field during a three weeks period. For the first brood this period would be much longer due to the slow development at this time of the year.

The eggs are laid singly, very commonly on the inner surface of the needles although they may also be found on the bundle sheaths, new shoots and the bud scales of newly formed buds; consequently in spraying these surfaces should be wetted in particular. These eggs are not easy to find because they are not much over 1 mm. in diameter, flat and of a yellowish color which blends somewhat with the foliage.

The first eggs laid in the spring may not hatch for some three weeks if the weather remains cold, and it is difficult to determine the proper time for spraying for this brood. If, as is the case in Nebraska, this brood is much less serious than the later broods it might be disregarded, at least until observations had determined the period over which the moths emerge and the approximate time at which the first eggs are likely to hatch. On the other hand, we have found that in hot summer weather tip moth egg will hatch within from 6 to 10 days from the time of laying. It is not unlikely that in the South this might be shortened to 5 days. The length of the egg stage has an important bearing on the time of application of the spray as will be seen later.

The Larvae

The yellowish larvae are less than 2 mm. in length at the time of hatching. They spin a small dense web, which is apparently coated with pitch, at the base of a needle cluster or near the base of the buds and under this protection begin feeding or burrowing in. Some of the small larva may bore through the bundle sheath and feed in the base of the needles for a time, later burrowing into the buds or new growth to continue their feeding. Damage by the larvae is confined to the new growth of the current year, the feeding usually starting in or near the buds and down through the shoot, the length injured depending on the size of the shoot and the number of larvae present. When full grown the larvae are only about one half inch in length.

There is no spread of an infestation during the larval stage because the larvae remain in the same tip if there is sufficient food. The spread of the infestation and the abundance of larvae depends on the distribution of eggs by the adult female moths. Injury to the new growth is not very apparent, without a careful inspection, until the larvae are about full grown and the tips turn brown.

The Pupae

When full grown the larvae transform to pupae within their burrows in the infested tip, although a few may spin cocoons on the outside of the shoot near the injury. These pupae average about 6 mm. in length and are of a reddish brown color. In Nebraska in summer at least 14 days elapses from the time of pupation until the moth emerges, but in the South the pupal period may in some cases be a few days less than this. The last brood, for the eastern tip moth, pupates in the tips as usual and remains in this stage during the winter.

POSSIBILITY OF USING INSECTICIDES

Since the larvae bore into the buds or shoots soon after hatching, and the burrow is protected by a small pitch-coated web, it is quite evident why insecticides are not effective against this stage of the insect. Dusting with contact and stomach insecticides during the larval stage showed no appreciable reduction in the amount of injury.

The egg is the one stage that is exposed to the application of a spray, and three applications of a white oil emulsion during the egg stage gave a marked reduction in the amount of damage to small western yellow pine trees, as later figures will indicate.

TIME OF SPRAYING FOR EGG STAGE

To be effective the spray must be applied before any of the eggs hatch. For the second brood and later broods during hot weather some of these eggs may hatch within 5 or 6 days, as stated before, consequently a spray applied 5 days after the first moths appear should hit all eggs laid up to that time and before any have hatched. But, since moths continue to emerge and lay eggs over a period two weeks or more it is necessary to spray at 5 day intervals for the later eggs. The application of three separate sprays

at 5 day intervals after the first moths appear would cover a total period of 20 days and thus subject practically all eggs of that brood to the insecticide before hatching.

DETERMINING TIME OF MOTH EMERGENCE

From the above discussion it is apparent that the first days on which moths begin to fly must be quite definitely determined if the best results are to be obtained with the spray. Since we have no data for the region, and furthermore, because the first emergence may vary as much as a week in different years, it is almost necessary to ascertain this time for each brood and for each year, at least until a number of year's observations have fixed the time within certain limits. This can be done by careful field observations, noting the empty, fresh pupal skins protruding from the infested tips or the first moths in flight; or perhaps much better by caging infested tips and noting the emergence of the moths in the cages. The length of the emergence could thus be determined by removing the newly emerged moths each day or two.

Almost any type of small cage could be used for this purpose; screen cages, small boxes covered with screen or muslin, mason jars with a muslin cover although green tips have a tendency to mold in these jars; or any type of parasite cage with vials fitted tightly on corks protruding from the side of the box with a hole thru them, or the few vials fitted into a few holes at one side of the box which is otherwise tightly closed and the insects thus coming into the vials because of their attraction to light. If screen is used a finer mesh than 14 mesh to the inch is necessary to prevent the escape of the moths.

For the second and later broods the infested tips should be collected for the cages about 8 or 9 days after the first pupae are found in the field, as this will give many of the larvae time to pupate and prevent their crawling away, but will still be prior to the emergence of the first moths. The infested

tips need only to be cut off a little below the affected part. A large number of tips should be taken, preferably several hundred or more, if the extremes of the emergence period are to be determined accurately. The cages should, of course, be placed where the temperature will approximate the outside temperature.

Tips containing overwintering pupae could be collected at any time in late winter or early spring before new growth starts on pine, or might even be collected in the fall and left in the cages all winter with fair results in getting the emergence period of the first brood moths.

USE AND RESULTS WITH WHITE OIL SPRAY

Volck Concentrate is the brand of white oil emulsion used in the experimental spraying in Nebraska on small yellow pine trees (Volck light and other strengths besides the "concentrate" are also made). This material might be obtained locally at about \$3.00 a gallon; or through an order placed with the California Spray Chemical Company, 204 Franklin St., New York City. The wholesale price from the Company in 5 gallon cans is somewhat cheaper.

The strength of Volck used and found most efficient as a spray was a 2% solution, or one part of the oil in 50 parts of water. The Volck is mixed directly with water. If there is no agitator on the spray tank used, or if small hand sprayers are used it is well to first thoroughly shake the oil in a small quantity of water in a glass jar or other container as this will help to get it in suspension before stirring it into the tank of water. It is essential that the oil is very well mixed and is kept in suspension. For small quantities of spray material the mixture can be figured at 2.56 fluid ounces for each gallon of water.

With three applications of a 2% solution of Volck at 6 day intervals during the egg stage of the second brood in Nebraska, the injury to small trees averaging less than 18 inches in height was reduced to 4% of the terminals and 5% of all lateral tips infested, as compared with 83% terminals and 54% laterals

infested in the unsprayed check plot. About 50 trees constituted each plot.

Only two applications of the 2% solution at 10 day intervals after the first moths emerged, did not give near the protection of the three applications at 6 day intervals, for the injury amounted to 45% terminals and 27% laterals infested.

A 1% solution, which consistently gave a complete kill of all eggs in the dipping experiments, was tried in the field but was found much less effective than the 2% material as a spray for the eggs. Here again three sprays gave much better protection than only two sprayings.

The following table summarizes the results of the above experiments and the advantage of the 2% solution of Volck applied three times at 6 day intervals can be seen when compared with the others and the unsprayed check plot;

<u>Strength used</u>	<u>No. of sprays</u>	<u>Interval between sprays in days</u>	<u>% terminals infested</u>	<u>% all lateral tips infested</u>
2%	3	6	4	5
1%	3	6	24	22
2%	2	10	45	27
1%	2	10	53	38
Unsprayed, check plot	-	-	83	54

Larger trees, averaging over two and a half feet in height, were sprayed at the same time as the above experiments with smaller yellow pine. However, these trees were very bushy and in many cases a dense mass of needles as a result of repeated tip moth attack, and doubtless this prevented many of the eggs being coated by the spray, thus accounting for less protection to these trees than to the smaller more open ones. The three applications of the 2% solution at 6 day intervals reduced the infestation in these bushy trees to 46% terminals and 34% laterals infested, as compared to 98% terminals and 78% laterals infested on the unsprayed plot.

There was no burning of the foliage or injury to these yellow pine tree with the 2% concentration of Volck, even though the spray was applied during some very hot days in July. It does not seem likely that injury would result to other species of pine from this strength of the white oil spray if the oil is kept well mixed.

As stated before, in the South the separate sprays should be applied at 5 day intervals instead of 6 as in Nebraska, at least until the shortest time in which the eggs will hatch has been determined. Tip moth eggs for observation and experimentation can be obtained by collecting moths in flight or on trees in the field. By placing one or two of these in a small vial with a pine needle a number of the females will lay their eggs on the needle or sides of the vial. The eggs from these moths are quite certain to be fertile and a high percentage of hatching is usually obtained.

OTHER INSECTICIDES

Several other insecticides gave a high percentage of mortality to eggs in the dipping experiments, and seedlings in a nearly dormant condition showed practically no injury from a similar treatment. Altho these materials were not as consistently efficient as the Volck, and are not as cheap, they have possibilities and might be tested as sprays in the field against the egg stage of the pine tip moth.

Nicotine Oleate

This proved to be quite an efficient dip, except for its comparatively high cost, when used at a strength of 1 part of free nicotine to 200 parts of other solution. It seems likely that this could be used on growing trees without injury, however, since it has not been tried in the field a few preliminary tests should be made to determine its effect on the foliage and new growth.

Nicotine oleate is made by combining a nicotine solution with oleic acid.

A stock solution is first made by mixing ten parts of a 40% solution of nicotine (as nicotine sulphate) with seven parts of oleic acid, and gives a thick soap. Then one part of this stock solution mixed with 46 parts of water gives a nicotine strength of 1 to 200.

Other nicotine sprays at strengths of 1 part free nicotine to 200 parts of other solution, or even 1 to 300, might give good results against the egg stage.

Miscible Oil

A number of miscible oils are put out under various commercial names and one called Sunoco, mixed at 1 part oil to 15 parts water, showed only a few failures of complete killing of the eggs when dipped in this solution. However, this is the strength usually recommended for only dormant plants and there is a possibility of injury to growing pine seedlings. Consequently this spray should be tested on growing trees to ascertain its effect before using it on any extensive scale.

SUMMARY

The egg stage of the pine tip moth is the one stage susceptible or exposed to the application of insecticides. Three applications of a 2% solution of Volck Concentrate at 6 day intervals during the egg stage gave a marked reduction in the injury to small yellow pine in Nebraska.

This spray might be used to protect seriously infested nursery stock or small plantations in the Southeast; but it ^{is} recommended that the three separate sprays of 2% Volck be applied at 5 day intervals after the appearance of the first moths in the Southern regions because of the possibility of the duration of the egg stage being somewhat shorter there. This applies to the second and later broods during hot weather - the duration of the egg stage would be much longer for the first brood and would have to be determined for

the region before the proper intervals between sprays for this stage could be recommended.

To determine the time of emergence of the moths and the number of broods that emerge each season, infested tips should be collected and caged for observation. For the second and later broods these collections should be made 8 or 9 days after the first pupae are noticed in the field. For the first brood infested tips may be taken at any time in the winter or early spring before new growth starts, since the insect overwinters in these tips in the pupal stage.

Signed - - L. G. Baumhofer,
Junior Entomologist.

3 X